LAYING AND REPAIRING A SIX-INCH WROUGHT IRON SUBMARINE PIPE LINE AT PORTLAND, MAINE[1]

By James W. Graham[2]

Peaks Island is located in Casco Bay about two miles from the city of Portland. The water supply for the Island has for some years been obtained from driven wells, but during the summer of 1919 the wells did not furnish sufficient water to keep the higher parts of the Island supplied. The population of the Island in the winter is about 1000, but in the summer season it reached 7000 and on holidays is perhaps 10,000. The wells supply ample water for the winter population, but the need of more water during the vacation season was apparent.

The city of Portland has an abundant supply of excellent water, but the cost of carrying it to the Island by the ordinary method of flexible joint cast iron pipe was prohibitive. It was therefore decided to lay a six-inch galvanized wrought iron pipe of standard weight, using recessed couplings. At sharp changes in the grade, Moran flexible cast iron joints were installed. The bottom of the harbor on the route selected was soft blue clay and silt for a considerable part of the way and except where the tide had carried away the silt, the pipe would sink about a foot and a half into the mud. In some places where the clay was fairly hard the pipe lay on the mud, exposed to the sea water.

It is well known that fresh water freezes at 32°, and salt water at 27°, and each winter the water in Portland harbor reaches 28°. It is therefore a question yet to be decided whether this line can be maintained in operation throughout the year. It is feared that enough of the line may be exposed to the flow of sea water to reduce the water inside the pipe to 32°. There was no ledge on the selected route except on the land sections and no logs or other obstructions, so that the pipe was well supported along its entire length.

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The line adopted left the east end of the city on an easy grade, so that 1800 feet from shore there was only ten feet of water at low tide. The next 1600 feet was a ship channel having 30 feet of water at low tide with gently sloping side banks. Beyond this channel the pipe reaches a part of the bay where for 5200 feet the depth of water varies between 10 and 17 feet at low tide. Next comes a channel 30 feet deep and 800 feet wide and then the flats leading to Little Diamond Island. The line then crosses this Island for 1500 feet and rises to a height of 40 feet. Between this Island and Peaks

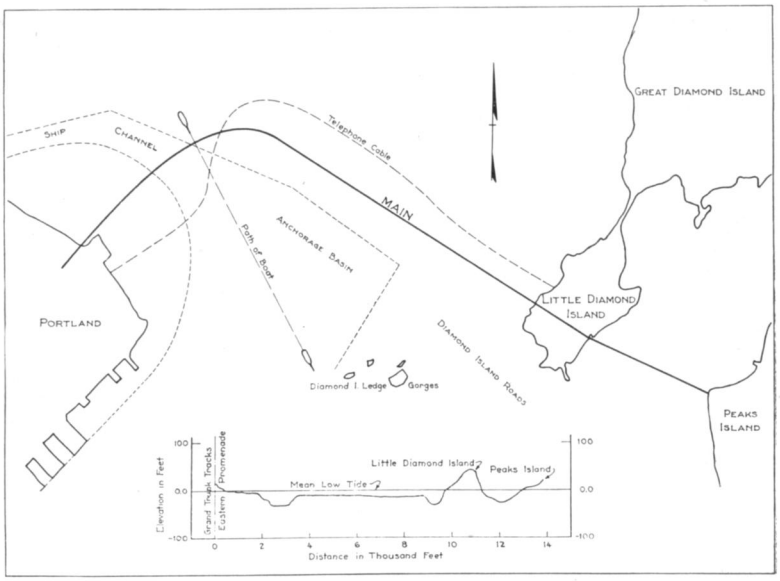

FIG. 1. PLAN AND PROFILE OF SUBMARINE PIPE LINE

Island is 2500 feet of water, with a depth of 25 feet and gently sloping banks. The rise and fall of the tide in Portland harbor is $9\frac{1}{2}$ feet so that a part of the line was laid in 40 feet of water. The total length of submarine pipe is 12,025 feet or about $2\frac{1}{4}$ miles.

For the purpose of laying the pipe a flat bottom scow was engaged. The boat was 26 feet wide and 56 feet long and draws about 3 feet of water when carrying no load. The sides stood 3 feet out of water and it was decked over. It carried a mast with derrick boom and a steam hoisting engine forward and had a cabin in the stern. The stanchions at each corner were very useful for fastening anchor lines.

A small tug was used for transporting the crew and moving the anchors used for holding the scow in position. The crew consisted of an engineer and deck hand on the scow, one man on the tug, three seamen, five pipemen and a foreman.

It was desired to begin the construction of the line as early in the spring as possible, but the prevailing wind storms during April held back the beginning of construction until about May 1, 1920. In beginning the work as much pipe was put on the deck of the scow as was possible without interfering with the working deck space and

FIG. 2. THE DECK OF THE SCOW

still more was stored in the hold. The scow was then towed around to the point of beginning on the shore of the city. Four 600 pound anchors were provided, two having 1200 feet of $3\frac{1}{2}$ inch manila rope each and two having 600 feet each of the same rope. Each anchor had a 75 foot drag line with a wooden float attached to one fluke. The tow boat carried an anchor several hundred feet off from each corner of the scow and dropped it to the bottom. The scow was held in position by these four anchors, one leading from each corner, and was pulled in the desired direction by passing the proper

anchor lines to the steam winch. When it was desired to move the anchors the tow boat would pick up the float attached to the fluke of the anchor and by pulling the line up short had no trouble in dragging the anchor to the desired position.

At high tide ten 20 foot lengths of pipe were dropped overboard near the high water mark and at the following low tide the pipe was screwed together and left lying in position on the mud with one end at half tide. The following high tide the scow was pulled near the low water end of the pipe and the end of the pipe was raised to the

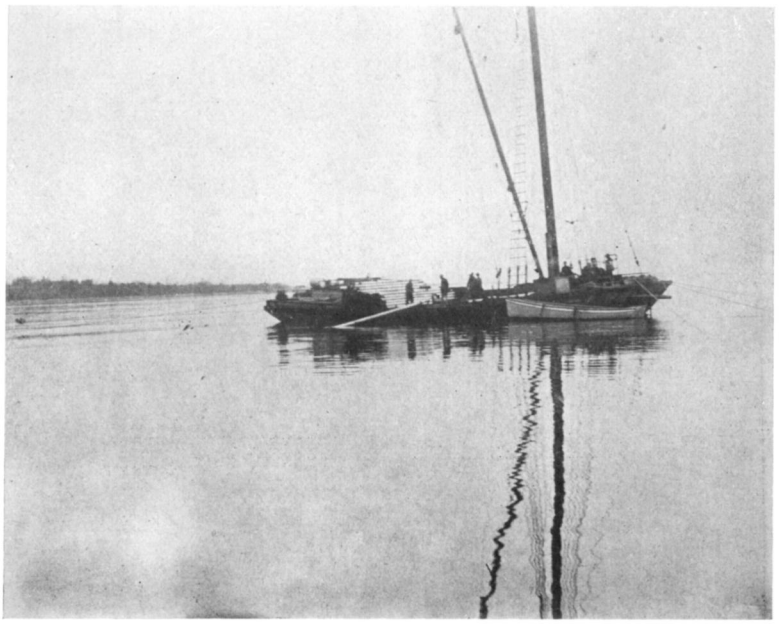

FIG. 3. LAYING THE PIPE

deck of the scow. The scow lay at right angles to the line of the pipe so that the work was done near her center. When she was pulled ahead she went sideways. The next piece of pipe was then screwed into the line with a 6 foot chain tongs. It was screwed up to refusal with five men on the tongs and the pipe threads out of sight within the recessed coupling. Each end of the coupling was then painted with red lead and oil. The scow was then pulled ahead 20 feet and another piece of pipe inserted in the line. When the depth of water became greater than 15 feet a rope was passed

under the pipe and over a plank lying across two dories. On this plank was a cleat to allow the pipe to be easily lowered. When the depth of water exceeded 25 feet, two sets of dories were used. The distance between these supports was about 150 feet. The pipe was left suspended to the scow and dories at night when the wind did not blow hard enough to rock the scow to any extent, but in rough weather the pipe was lowered to the bottom and picked up the following morning. We were not forced to lower the pipe and pick it up again in the deeper parts of the line.

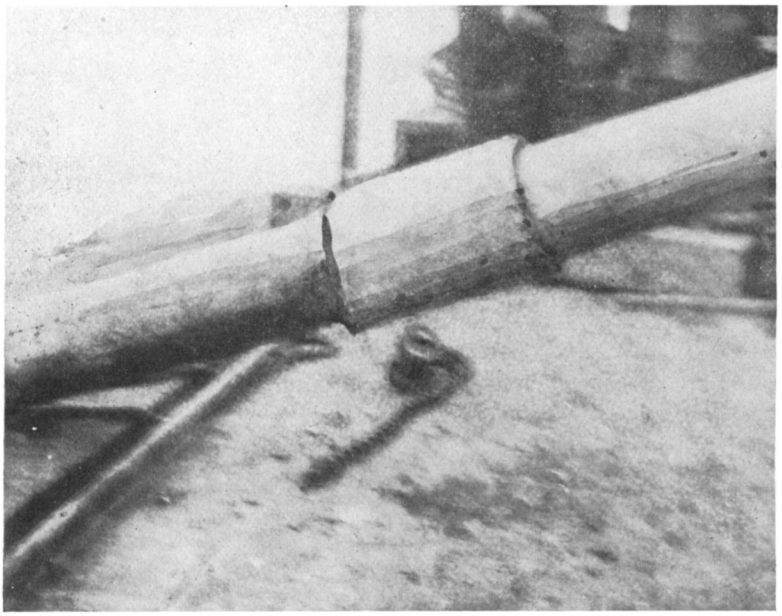

FIG. 4. THE SLEEVE IN PLACE

When the scow finally approached the Island shore the pipe was laid in the regular way at high tide to a point well above low water. At low tide, men working on the flats connected up additional pipe. When the pipe end was lowered into the water it was carefully plugged in order that no water might get inside. The work was carried on the same way between Little Diamond and Peaks Island. The distance was 2500 feet and the water was comparatively shallow. The wrought iron pipe was carried up to a point near half tide where

it was connected to cast iron pipe by a cast iron sleeve. That part of the line crossing Little Diamond Island and on Peaks Island and Portland necessary to connect with existing mains was laid with cast iron pipe. The line crossing Little Diamond Island, about 1500 feet in length, was laid on the surface of the ground and the joints were made of Lead-Hydro-Tite. It took two days for our men to learn to handle this compound, and then the work proceeded smoothly. It became evident that a gasoline burning furnace built

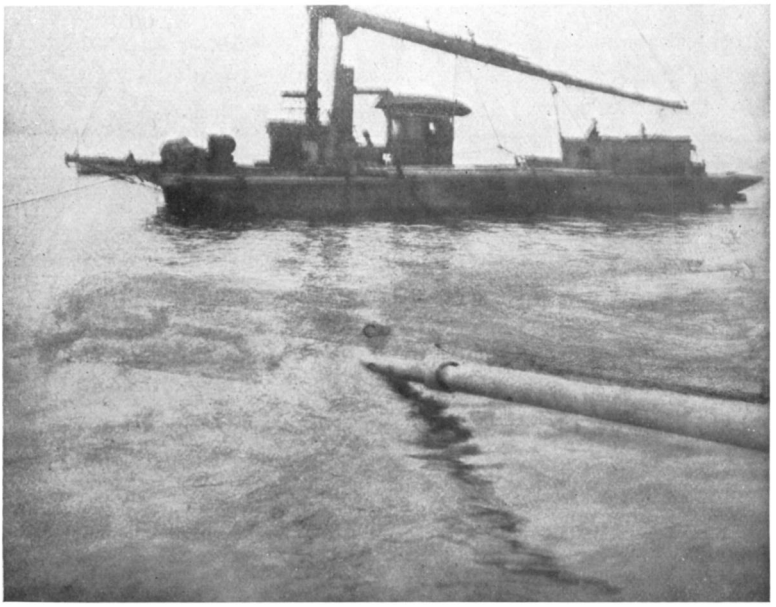

FIG. 5. LAST VIEW OF SLEEVE

especially for melting this material was essential and would pay for itself in a short time.

After the entire line was installed and had been working a few days a 2-inch Empire meter was installed at the Portland end on a bypass and the gate at the far end was closed over night. All water entering the line passed through the meter. The reading of the meter the following morning showed that the line was perfectly tight, the meter not having moved.

In October it was decided to bury the land portions of this line below frost. This involved lowering the 1500 feet across Little

Diamond Island a part of which was ledge. This was accomplished by making the trench along side the pipe line, and the blasting was done without disturbing the line. The pipe was then lowered into the ditch a little at a time without shutting off the water for more than an hour or so. The Lead-Hydro-Tite joints stood this moving successfully. A few of them leaked a little when first lowered, but the ditch was left open a few days and the leakage stopped. On the shore of Peaks Island a 6-inch Empire Compound Meter, a 6-inch Ross Pressure Regulator, and a 6-inch check valve were installed with proper by-passes. On Peaks Island is a standpipe with the overflow at an elevation of 135 feet above the tide water. On the Portland end the supply for the line was equal to a head of 250 feet above tide.

The Ross Regulator was set to close when the water in the standpipe was 3 feet below the top and during the night the submarine part of the line was subject to a pressure of 280 feet. When the water was first turned into the Peaks Island System, it happened that the wells had been pumped nearly dry, the standpipe was empty and only the low parts of the system were getting water. The head on the Island end was equal to about 30 feet when we turned the supply from the city into the Island System. The meter showed a flow for the first few minutes at the rate of 600,000 gallons per 24 hours. The total length of this 6-inch line was 14,050 feet. The loss of head in the line when first turned on was 220 feet. This gives a value of "C" in the Williams and Hazen tables of 125.

The 12,025 feet of wrought iron pipe was laid in 22 working days, an average of 546 feet per day. The best day's work was 1160 feet in 10 hours. The poorest day's work was 150 feet. The total cost of the entire 14,050 feet of main was $38,400. This included burying the cast iron pipe below frost, legal and engineering expenses and all overhead charges. The direct cost of the submarine part of the line was $26,125 for 12,025 feet or $2.17 per linear foot.

The cost of the pipe delivered in Portland was $1.56 per foot, leaving 61 cents per foot for the cost of the fittings and laying the pipe.

On Tuesday, November 2, 1920, there was a heavy storm with a high wind at Portland. A large steel steamer lying at anchor nearly a mile from the pipe line dragged her anchor about 2 o'clock in the morning until the anchor caught in the pipe line in the pottom of the channel in 30 feet of water. Where the anchor

hit the pipe it bent the pipe to a 90° angle, broke a piece out of the top of the pipe at the bend and pulled the ends apart at the break until there was an opening of 100 feet between them. The point of the break was nearly 3000 feet from the Portland shore and this section of pipe was pulled off shore 9 feet leaving an open space of this length where the galvanized and cast iron pipe joined.

We filled this 9-foot space with a piece of cast iron pipe, and then attached an air compressor to the Portland end of the line. This

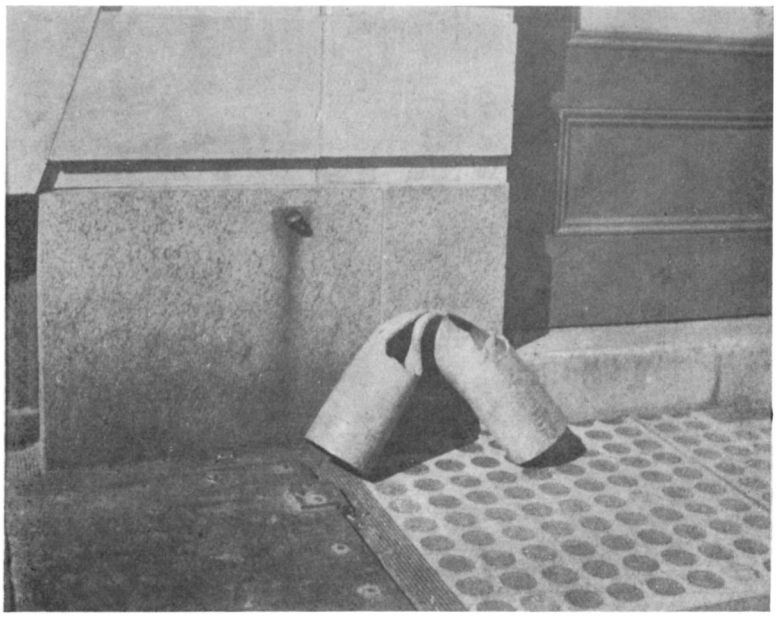

FIG. 6. SIX-INCH PIPE BENT BY ANCHOR

machine was of a capacity to furnish 23 cubic feet of free air per minute. It required about 2 hours for the air to drive the water out of the open end of the pipe at the break. Then the air appeared at the surface, causing the water to appear to boil over an area 10 feet in diameter.

A diver was sent down to attach a line to the end of the pipe from which the air came, and find the other end. He found the pipe buried about 2½ feet in the soft mud, but was able to dig out a hole and get a line tied to the pipe. He could not find the other end of

the break and it was necessary to carry the air compressor to Little Diamond Island and connect it to that end of the line. This was effective and showed the two ends to be 100 feet apart. A line was then attached to this end of the pipe and an attempt was made to raise both ends to the surface and connect them together with three Moran joints in the line and then lower them to the bottom. They could be raised to the surface, but when lowered again invariably broke off 3 or 4 lengths back from the end.

FIG. 7. A MORAN JOINT

Thus at every attempt the opening between the two ends became greater. We attached lines to the pipe 100 feet apart and tried working them up together but with no better success. We determined that the suction of the mud on the pipe was very great and held the pipe with such force that it would break off or pull out at the first coupling out of the mud. Furthermore, the wind blew almost continuously at a rate that tossed the scows around and added to the strain on the pipe. The weather would not allow two successive days work and the expense of the crew and boats was about $250 daily. After working from November 3 to Decem-

ber 10, and spending $5700, it was decided to wait until the winter weather was past before making any further attempts to repair the line.

It was shown by examination of the pipe that broke off in attempting to raise it that the pipe would bend a little before the joint would fail and it seemed that if the joint was a little stronger it would be possible to raise and lower the pipe as often as desired.

We accordingly designed and tested a method of strengthening the joints. A piece of 8-inch galvanized wrought iron pipe was cut off to a length of 13 inches. This was placed over the coupling between two pieces of 6-inch wrought iron pipe and held in place by small wooden wedges. The space between the 6-inch pipe and coupling and the 8-inch sleeve was then filled with Leadite. The Leadite cooled in 2 or 3 minutes so that the collars and clay could be removed. We then suspended the section of pipe at its two ends and piled pigs of lead on a platform suspended at the center by a rope on each side of the joint. It required 3800 pounds of lead to exceed the elastic limit of the pipe metal and put a permanent bend in the pipe.

A joint using Metallium for filling was tried and tested by putting one end of the pipe under a building and raising the other end. In both cases the pipe bent but the sleeve held the coupling without any sign of movement nor was there any sign of crushing either the Leadite or Metallium.

On April 12 of this year the wind moderated and we again took up the work where it was left in December. The work was completed in two weeks at a cost of $3600, in the following manner. We used two flat bottomed scows, 20 by 40 feet, each equipped with gasoline winches, a tug boat and a crew of ten men. The air compressor was attached to the Portland end of the pipe to force the water out and keep it out in order that it might be lighter to raise. We used no diver but dragged an anchor along the bottom until it caught the pipe. The pipe was raised a few feet from the bottom with the anchor. A line was swept under it and a slip knot tied and carried to the hoist. The pipe was raised about ten feet more and another line swept under the pipe as far as possible toward where it emerged from the mud.

The second scow then lifted a few feet on this line to loosen the suction of the mud, and another line swept still further back. This operation was repeated until the end of the pipe was up on the scow.

The laying of pipe was immediately begun, each coupling being covered with an 8-inch sleeve and the space filled with Leadite. The tide was low and little wind blowing, and beginning at the middle of the deep channel and moving toward Little Diamond Island, we laid 200 feet of pipe and lowered it to the bottom before dark with a plug screwed into the end. The following day at low tide the end was easily raised from the bottom as all the joints were then reinforced. The laying of pipe was continued.

This work was continued until the pipe was laid up to where the water was about 12 feet deep at low tide. The Little Diamond Island end of the pipe was then raised and 100 feet of pipe removed leaving the two ends five lengths of pipe apart. The two scows were then swung around end to end ranging along the line of the pipe with the pipe hanging at their sides. The five lengths of pipe necessary to complete the line were then placed in position with four Moran joints inserted to provide flexibility. The next move was the lowering of the pipe and at the same time pulling it to one side forming a slight curve in the line. The air compressor showed the line to be tight, and the same day we began supplying water to Peaks Island.

The work was carried on under the immediate supervision of Harry U. Fuller of the Portland Water District.